Effective Date: November 06, 2013
Revision D

GSFC JPSS CMO
November 8, 2013
Released

Joint Polar Satellite System (JPSS) Ground Project
Code 474
474-00089

Joint Polar Satellite System (JPSS) Operational Algorithm Description (OAD) Document for the Granulate Ancillary (GRAN ANC) Software

For Public Release

The information provided herein does not contain technical data as defined in the International Traffic in Arms Regulations (ITAR) 22 CFC 120.10. This document has been approved For Public Release to the NOAA Comprehensive Large Array-data Stewardship System (CLASS).

National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

Joint Polar Satellite System (JPSS)
Operational Algorithm Description (OAD) Document for the Granulate Ancillary (GRAN ANC) Software
JPSS Electronic Signature Page

Prepared By:

Bruce Guenther
JPSS Data Products and Algorithms SDR Lead
(Electronic Approvals available online at (https://jpssmis.gsfc.nasa.gov/mainmenu_dsp.cfm)

Approved By:

Eric Gottshall
DPA Manager
(Electronic Approvals available online at (https://jpssmis.gsfc.nasa.gov/mainmenu_dsp.cfm)

Goddard Space Flight Center
Greenbelt, Maryland

Preface

This document is under JPSS Ground Algorithm ERB configuration control. Once this document is approved, JPSS approved changes are handled in accordance with Class I and Class II change control requirements as described in the JPSS Configuration Management Procedures, and changes to this document shall be made by complete revision.

Any questions should be addressed to:

JPSS Configuration Management Office
NASA/GSFC
Code 474
Greenbelt, MD 20771

Change History Log

Revision	Effective Date	Description of Changes (Reference the CCR & CCB/ERB Approve Date)
Original	06/03/2011	This version incorporates **474-CCR-11-0104** which converts D41854, Operational Algorithm Description Document for the Granulate Ancillary Software, Rev B dated 03/17/2010 to a JPSS document, Rev -. This was approved by the JPSS Ground Algorithm ERB on June 3, 2011.
Revision A	01/18/2012	**474-CCR-11-0278:** This version baselines 474-00089, Joint Polar Satellite System (JPSS) Operational Algorithm Description (OAD) Document for the Granulate Ancillary (GRAN ANC) Software, for the Mx 6 IDPS release. This CCR was approved by the JPSS Algorithm ERB on January 18, 2012.
Revision B	05/14/2013	**474-CCR-13-0948:** This version authorizes 474-00089, JPSS OAD Document for Gran ANC Software, for the Mx 7.0 IDPS release. Includes Raytheon PCR032720; 474-CCR-13-0916/ECR-ALG-0037: Update applicable OAD filenames/template/Rev/etc. for Mx7 Release.
Revision C	07/10/2013	**474-CCR-13-1101:** This version authorizes 474-00089, JPSS OAD Document for Gran ANC Software, for the Mx 7.1 IDPS release. Includes Raytheon ECR-ALG-0039/PCR033576; OAD: Gran-Anc OAD update to clarify wind direction, in section 2.1.1.2.1.2.
Revision D	11/06/2013	**474-CCR-13-1288:** This version authorizes 474-00089, JPSS OAD Document for Gran ANC Software, for the Mx 8.0 IDPS release. Includes administrative changes authorized by interoffice memo and Raytheon PCR033834; OAD: Update Gran Anc OAD for NOGAPS to NAVGEM (FNMOC) change, in section 2.1.3.

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS)

OPERATIONAL ALGORITHM DESCRIPTION DOCUMENT FOR GRANULATE ANCILLARY (GRAN ANC)

SDRL No. 141
SYSTEM SPECIFICATION SS22-0096

RAYTHEON COMPANY
INTELLIGENCE AND INFORMATION SYSTEMS (IIS)
NPOESS PROGRAM
OMAHA, NEBRASKA

This data was developed pursuant to Contract Number F04701-02-C-0502 with the US Government under subcontract number 7600002744. The US Government's right in and to this copyrighted data are as specified in DFAR 252.227-7013, which was made part of the above contract.

IAW DFAR 252.227-7036, Raytheon hereby declares that, to the best of its knowledge and belief, the technical data delivered under Subcontract No. 7600002744 is complete, accurate, and complies with all requirements of the Subcontract.

TITLE: NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS) OPERATIONAL ALGORITHM DOCUMENT FOR GRANULATE ANCILLARY (Gran Anc)

APPROVAL SIGNATURES:

_____

Stephen E. Ellefson Date
ING/PRO Lead

_____

Gabriela A. Ostler Date
Mission Assurance and Enterprise Effectiveness (MAEE)

Northrop Grumman Space & Mission Systems Corp.
Space Technology
One Space Park
Redondo Beach, CA 90278

Engineering & Manufacturing Development (EMD) Phase
Acquisition & Operations Contract

CAGE NO. 11982

Operational Algorithm Description Document for the Granulate Ancillary Software

Document Number: D41854
Document Date: Sep 29, 2011 **Revision: C4**

PREPARED BY:

Alain Sei *Date* *A&DP Lead*	Paul D. Siebels *Date* *IDPS Processing SI Software Manager*

ELECTRONIC APPROVAL SIGNATURES:

Alain Sei *Date* *A&DP Lead & ACCB Chair*	Stephen E. Ellefson *Date* *IDPS Processing SI Lead*
Bob Hughes *Date* *A&DP Deputy & ARB Chair*	

Prepared by
Northrop Grumman Space Technology
One Space Park
Redondo Beach, CA 90278

Prepared for
Department of the Air Force
NPOESS Integrated Program Office
C/O SMC/CIK
2420 Vela Way, Suite 1467-A8
Los Angeles AFB, CA 90245-4659

Under
Contract No. F04701-02-C-0502

This document has been identified per the NPOESS Common Data Format Control Book – External Volume 5 Metadata, D34862-05, Appendix B as a document to be provided to the NOAA Comprehensive Large Array-data Stewardship System (CLASS) via the delivery of NPOESS Document Release Packages to CLASS.

Northrop Grumman Space & Mission Systems Corp.
Space Technology
One Space Park
Redondo Beach, CA 90278

NORTHROP GRUMMAN

Raytheon

Revision/Change Record

Document Number D41854

Revision	Document Date	Revision/Change Description	Pages Affected
---	9-17-04	Initial Release of Gridding and Regridding OAD.	All
A1	7-22-05	Reflects Science To Operational Code Conversion. 07 Nov05 – Reflects changes based on comments from I-P-O DDPR held on 07Nov05.	All
A2	6-30-06	30 Jan 06 - The G/RG OAD is being split into a separate Gran Anc OAD. Updated Title of OAD. 23 Mar06 – Updated copyright year on coversheet and began looking at what information remains as Granulate Ancillary is separated into its own OAD. Replaced old Unit Test (UT) with a 14 Feb06 VIIRS Granulate Ancillary UT and 21Mar06 CrIS Granulate Ancillary UT, then updated Table of Contents to capture these sections 5.1.1 and 5.1.2. 18 May 06 - Incorporated detailed design review comments. Updated description of Gran Anc controller and sub-algorithm processing. 29 Jun 06 - Incorporated code and unit test review comments. 30 Jun 06 - Added new document ID number to signify initial release of this IDPS produced document.	All
A3	11-14-06	Removed VIIRS Relative Humidity from output product list. 2.2.3. Updated detailed description 2.3.1.	All
A4	9-19-07	Added initial OMPS NP and TC information.	All
A5	3-24-08	Added GranulateSkinTemp.	6
A6	4-11-08	Added information regarding the use of TOMS V8 temperature profile climatology in OMPS.	3, 8
A7	4-30-08	Table 2.2-1: Changed Relative Humidity to Specific Humidity; Added Spacecraft Diary RDRs and the CrIS SDR Exit Angles IP to Table 2.2-1 (Inputs). Removed Section 2.2.4.2 (CrisAncLandFractionType).	4,5,6
A8	8-11-08	Reformatted to conform with template D41851 format. Updated Graceful Degradation. New cover sheet, update references, acronym list, prepare for peer review.	All
A9	2-09-09	Addressed peer review AIs. Addressed Class 2 RFAs. Updated for PCR 14267 (added inputs to several algorithms and added ProAncCrisGranulateSpecSurfHumidity) and corrected several incorrect units. Fixed typo.	All
A	2-11-09	Revision rolled to Rev A for ARB/ACCB delivery. Updated text on page 3 to reflect both NPP and NPOESS eras – ACCB comment.	All

Northrop Grumman Space & Mission Systems Corp.
Space Technology
One Space Park
Redondo Beach, CA 90278

NORTHROP GRUMMAN

Raytheon

Revision/Change Record

Document Number D41854

Revision	Document Date	Revision/Change Description	Pages Affected
B1	4-1-09	Updated units of VIIRS granulated total column ozone from Dobson Units to atm-cm as part of PCR 020153	4
B2	5-28-09	Added TM 2006.510.0077-Rev-A to Table 1.	2
B3	6-10-09	Section 2.1: Broke inputs into two parts, one dealing with inputs from Ingest and one dealing with inputs from temporal interpolation.	3 - 5
B4	10-12-09	PCR21311 - Added the adjustment for surface pressure in the surface temperature and water vapor mix ratio	7-8
B5	12-01-09	Resolved RFA No. 301 and updated subcontract number	Title pg
B6	1-20-10	PCR20164 – Updated to add the NAAPS and AOT Climatology	8
B7	2-24-10	Updated for TIM	All
B	3-17-10	Incorporated TIM comments and prepared for ARB/ACCB	All
C1	10-19-10	Updated due to document convergence	All
C2	11-17-10	Updated for ADL Phase 2 work	4
C3	12-16-10	Added new products to support NHF	All
C4	09-29-11	Updated for PCR026646.	1-5, 11

Table of Contents

List of Figures

List of Tables

1.0 INTRODUCTION

1.1 Objective

The purpose of the Operational Algorithm Description (OAD) document is to express, in computer-science terms, the remote sensing algorithms that produce the National Polar-Orbiting Operational Environmental Satellite System (NPOESS) end-user data products. These products are individually known as Raw Data Records (RDRs), Temperature Data Records (TDRs), Sensor Data Records (SDRs) and Environmental Data Records (EDRs). In addition, any Intermediate Products (IPs) produced in the process are also described in the OAD.

The science basis of an algorithm is described in a corresponding Algorithm Theoretical Basis Document (ATBD). The OAD provides a software description of that science as implemented in the operational ground system -- the Data Processing Element (DPE).

The purpose of an OAD is two-fold:

1. Provide initial implementation design guidance to the operational software developer.
2. Capture the “as-built” operational implementation of the algorithm reflecting any changes needed to meet operational performance/design requirements.

An individual OAD document describes one or more algorithms used in the production of one or more data products. There is a general, but not strict, one-to-one correspondence between OAD and ATBD documents.

1.2 Scope

The scope of this document is limited to the description of the core operational algorithms required to create the Granulated Ancillary products. The theoretical basis for these algorithms is described the VIIRS Earth Gridding Algorithm Theoretical Basis Document (ATBD), 474-00028.

1.3 References

The primary software detailed design documents listed here include science software documents and source code references.

1.3.1 Document References

The science and system engineering documents relevant to the algorithms described in this OAD are listed in Table 1.

Table 1. Reference Documents

Document Title	Document Number/Revision	Revision Date
VIIRS Earth Gridding Algorithm Theoretical Basis Document (ATBD)	474-00028	Latest
JPSS Environmental Data Record (EDR) Production Report (PR) for NPP	474-00012	Latest
JPSS Environmental Data Record (EDR) Interdependency Report (IR) for NPP	474-00007	Latest
NPP Mission Data Format Control Book and App A (MDFCB)	429-05-02-42_MDFCB	Latest

Document Title	Document Number/Revision	Revision Date
JPSS Common Data Format Control Book - External - –Block 1.2.2 (All Volumes)	474-00001-01-B0122 CDFCB-X Vol I 474-00001-02-B0122 CDFCB-X Vol II 474-00001-03-B0122 CDFCB-X Vol III 474-00001-04-01-B0122 CDFCB-X Vol IV Part 1 474-00001-04-02-B0122 CDFCB-X Vol IV Part 2 474-00001-04-03-B0122 CDFCB-X Vol IV Part 3 474-00001-04-04-B0122 CDFCB-X Vol IV Part 4 474-00001-05-B0122 CDFCB-X Vol V 474-00001-06-B0122 CDFCB-X Vol VI 474-00001-08-B0122 CDFCB-X Vol VIII	Latest
JPSS Common Data Format Control Book - External - Block 1.2.3 (All Volumes)	474-00001-01-B0123 CDFCB-X Vol I 474-00001-02-B0123 CDFCB-X Vol II 474-00001-03-B0123 CDFCB-X Vol III 474-00001-04-01-B0123 CDFCB-X Vol IV Part 1 474-00001-04-02-B0123 CDFCB-X Vol IV Part 2 474-00001-04-03-B0123 CDFCB-X Vol IV Part 3 474-00001-04-04-B0123 CDFCB-X Vol IV Part 4 474-00001-05-B0123 CDFCB-X Vol V 474-00001-06-B0123 CDFCB-X Vol VI 474-00001-08-B0123 CDFCB-X Vol VIII	Latest
NPP Command and Telemetry (C&T) Handbook	D568423 Rev. C	30 Sep 2008
JPSS CGS Data Processor Inter-subsystem Interface Control Document (DPIS ICD) Vol I – IV	IC60917-IDP-002	Latest
Joint Polar Satellite System (JPSS) Program Lexicon	470-00041	Latest
VIIRS Gridding / Regridding DDD	Y3246 Ver. 5 Rev. 6	17 Sep 2004
VIIRS Gridding / Regridding Component Level Software Architecture	Y3264 Ver. 5 Rev. 6	17 Sep 2004
VIIRS Gridding / Regridding Component ICD	IC60822 Ver. 5 Rev. B	17 Sep 2004
VIIRS Gridding / Regridding Data Dictionary (Area Weighting)	DD60822 Ver. 5 Rev. A	17 Sep 2004
VIIRS-LAND-Albedo-DDD.doc	Y2483 Ver. 5 Rev. 4	24 May 2004
Operational Algorithm Description Document for VIIRS Surface Reflectance Intermediate Product (IP) Software	474-00069	Latest
Operational Algorithm Description Document for VIIRS Gridded Surface Albedo (GSA) Intermediate Products (IP)	474-00078	Latest
Operational Algorithm Description Document for Gridding/Granulation (G/G) and VIIRS Gridded Intermediate	474-00075	Latest

Document Title	Document Number/Revision	Revision Date
Products (GIP)		
Operational Algorithm Description Document for VIIRS Geolocation (GEO) Sensor Data Record (SDR) and Calibration (CAL) SDR	474-00090	Latest
Em041210ISIN-M	NP-EMD.2004.510.0054	10 Dec 2004
NGAS/AM&S Technical Memo – Instruction for Time and Space Granulation of NWP Ancillary Data	NP-EMD.2006.510.0077 Rev-A	13 Mar 2007
NGAS/AM&S Technical Memo – Instructions to Generating Temperature Ancillary Data for OMPS TC Retrieval	NP-EMD.2007.510.0062	23 Oct 2007

1.3.2 Source Code References

The science and operational code and associated documentation relevant to the algorithms described in this OAD are listed in Table 2.

Table 2. Source Code References

Reference Title	Reference Tag/Revision	Revision Date
Note: The Granulate Ancillary algorithm was originally dropped by NGST/DPSE [A&DP] as part of Drop 2.8 and was rejected, then locally derived by IDPS, Raytheon, Omaha, NE. Another Gridding drop, 4.4. was also received at IDPS, containing only a gridding update.	Note: See the Operational Algorithm Description Document For Gridding - Granulation (G - G) And VIIRS Gridded Intermediate Products (GIP) for further description of drops, tech memos and dates.	22 Sep 2004 10 Jan 2007
VIIRS Gridding/Granulation (G/G) operational software	B1.4 (OAD Rev A1)	22 Jul 2005
VIIRS Gridding/Granulation (G/G) operational software	B1.5 (OAD Rev A4)	19 Sep 2007
VIIRS Gridding/Granulation (G/G) operational software	B1.5.X.1 (OAD Rev A8)	11 Aug 2008
ACCB (no code updates)	OAD Rev A	11 Feb 2009
PCR21311	Sensor Char Build SC-2 (OAD Rev B4)	12 Oct 2009
ACCB (no code changes)	OAD Rev B	17 Mar 2010
Convergence Update (No code update)	(OAD Rev C1)	19 Oct 2010
VIIRS Snow Cover - Algorithm Development Library	Mx1.5.4.00 (OAD Rev C2)	17 Nov 2010
PCRs024754, 24930, & 024935	Mx1.5.5_B (OAD Rev C3)	16 Dec 2010
PCR026646 (OAD update for ADL)	(OAD Rev C4)	29 Sep 2011
OAD transitioned to JPSS Program – this table is no longer updated.		

2.0 ALGORITHM OVERVIEW

The Granulate Ancillary software prepares ancillary data inputs for use by EDR processing by determining the optimum value of an attribute for the time and space of the observation data and subsequently, this processing is done on a per sensor basis. At its highest level, the Granulate Ancillary component is broken into several distinct parts: granulation of VIIRS ancillary, granulation of CrIMSS ancillary data, and granulation of OMPS TC ancillary data. Each of the previous parts results in granulated products for the respective sensor. OMPS NP uses data produced by OMPS TC granulation.

Granulation of Ancillary data maps external data to the swath. Figure 1 outlines the Granulate Ancillary process.

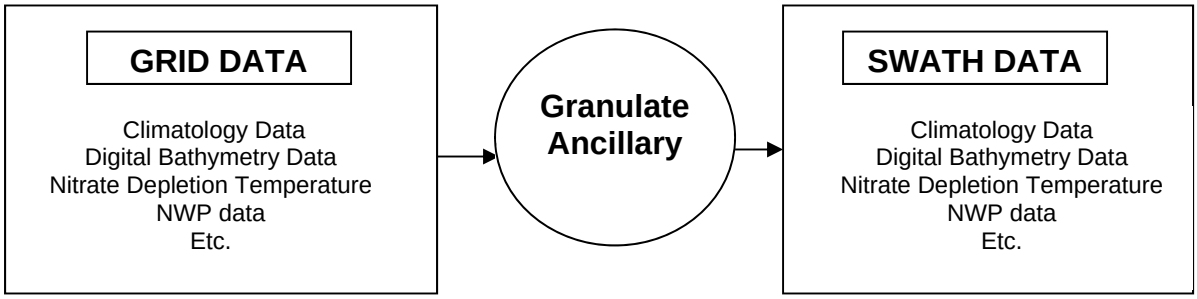

Figure 1. Granulate Ancillary

2.1 Granulate Ancillary Description

The Granulate Ancillary algorithm and theoretical basis for it are described in the VIIRS Earth Gridding Algorithm Theoretical Basis Document (ATBD), 474-00028. The current Granulate Ancillary algorithm described in its ATBD, applies for all Suomi National Polar-orbiting Partnership (SNPP) and NPOESS sensors. Granulate Ancillary creates products for VIIRS, CrIS, and OMPS TC.

A generic granulation framework was developed to perform granulation in the most common granulation scenario, the granulation of cylindrical equidistant (CED) formatted ancillary data. The generic granulate ancillary framework provides the ability to granulate ancillary data that is represented using a CED map projection with data values placed at regular intervals (e.g. every 0.5 degrees). NCEP data fits these requirements. The ancillary data may contain data for the entire Earth or a smaller region. While the generic ancillary granulation framework will handle normal cases, complex situations may require a sensor-specific sub class to extend functionality. The generic ancillary granulation framework is written in C++ and can be used from a C++ algorithm.

The granulation of precipitable water, surface temperature, and wind speed to VIIRS sensor space was converted to use the generic granulation framework when those algorithms were made ADL compatible. Other algorithms do not use the generic granulation framework.

2.1.1 Interfaces

Granulation of ancillary data may be executed within either a Sensor Data Record (SDR) executable or EDR executable. If a granulated product is needed by multiple downstream algorithms, during normal processing, the SDR algorithm granulates the product after the geolocation data item has been created by the algorithm. If the granulated product is only needed by algorithms within a single process, the granulation may be performed by EDR algorithm. Where the granulation is performed is controlled by configuration guides which accommodate graceful degradation and substitute processing. The Infrastructure Subsystem (INF) provides tasking details (e.g. which granules to process). The Data Management Subsystem (DMS) SI provides data storage and retrieval capability.

2.1.1.1 Inputs

2.1.1.1.1 From Ingest

The external ancillary data and their sources are listed in Table 3. Some of these data are preprocessed by either the factory or the Ingest subsystem.

Table 3. Inputs for the Granulation of Ancillary Data

Input	Description	Sensor
Digital Bathymetry Data	Ocean Depth from University of California at San Diego, SRTM30_PLUS database(http://topex.ucsd.edu/WWW_html/srtm30_plus.html) (units: m; range: -11000 – 9000)	VIIRS
Nitrate Depletion Temperature	Nitrate depletion temperature created by Kendall Carder of Univ of South Florida (Equal angle raster 1024 x 2048) (units: K; range: 271 – 313)	VIIRS
Total Column Ozone	Total Column Ozone from NWP models (units: atm-cm; range: 0.080 – 0.650) (ING converts to atm-cm from Dobson Unit)	VIIRS
Surface Pressure	Surface Pressure in Pa from NWP models (units: hPa; range: 300 – 1080 hPa) (ING converts Pa to hPa)	VIIRS, CrIS, and OMPS TC
Temperature at Pressure Levels	Temperature at NWP levels from NWP models (units: K; range: 150 – 320)	VIIRS, CrIS, OMPS TC
Surface Air Temperature	NCEP GFS (http://www.nws.noaa.gov/climate.html) Air Temperature at 2m (units: K; range: 183 – 328)	VIIRS, CrIS
Skin Temperature	Skin Land/Water Temperature (units: K; range: 180 – 350)	CrIS (used for CrIS GD)
Precipitable Water	Precipitable water in cm from NWP models (units: cm; range: 0 –130) (ING converts from kg/m^2 (kg/m^2 is equivalent to mm) to cm)	VIIRS
Geopotential Height at Pressure Levels	Geopotential height in meters at NWP levels from NWP models (units: gpm; range: -200 – 33000)	VIIRS, CrIS
Tropopause Geopotential Height	Geopotential height of tropopause in meters from NWP models (units: gpm; range: 5000 – 20000)	VIIRS
U-Wind, V-Wind	U & V Wind Components (units: m/s; range: -120 – 120)	VIIRS
Surface Specific Humidity	Specific Humidity at 2m (units: kg/kg; range: 0.002 – 0.040)	VIIRS, CrIS
Surface Geopotential Height	Smoothed height of the earth's surface (units: gpm; range: -1000 – 9000) Created from NCEP data.	VIIRS, CrIS

Input	Description	Sensor
Terrain Geopotential Height	Terrain Height (geopotential) (units: gpm; range: -1000 – 9000). Created from a DEM (Terrain Eco Tiles).	VIIRS, CrIS
Cloud Top Pressure	Cloud Top Pressure (units: hPa; range 200 -800)	OMPS TC
Surface Pressure Climatology	Surface Pressure in hPa from TUG87 (units: hPa; range: 475 – 1013.25 hPa)	OMPS TC
UV Surface Reflectance	Fraction of the total possible amount of ultraviolet energy reflected from the surface (Fraction; 0 – 1)	OMPS TC
Temperature Profile Climatology	TOMS V8 temperature profile with data at 11 Umkehr pressure layers (Kelvin; 185 - 290)	OMPS TC

2.1.1.1.2 From Temporal Interpolation

For dynamic ancillary data within time periods not covered by the supplied Ingest products, temporal interpolation is needed. This temporal interpolation is provided by a transient process that is run after Ingest is finished processing ODAD or SDAD. This temporal interpolation process can provide the following inputs for Granulate Ancillary; Surface Pressure, Temperature at Pressure Levels, Surface Air Temperature, Skin Temperature, Water Vapor Mixing Ratio at Pressure Levels, Geopotential Height at Pressure Levels, MSL Pressure, Precipitable Water, Tropopause Height, U-Wind, V-Wind, Surface Specific Humidity, Surface Geopotential Height, and Tropospheric Ozone. See diagram below for a representation of this process.

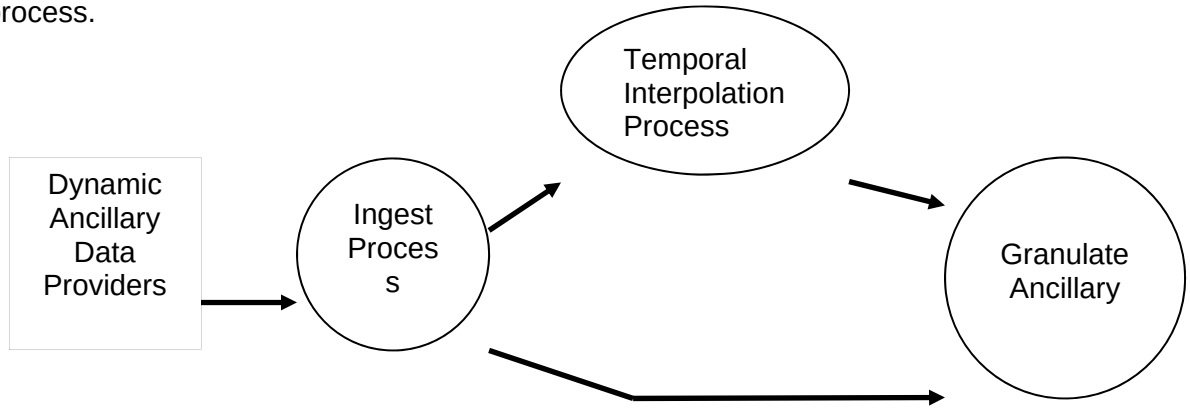

Figure 2: Temporal Interpolation

2.1.1.2 Outputs

Outputs from Granulate Ancillary are mostly products of the same name as those listed in Column 1 of Table 3 except where noted. Outputs have been mapped to the swath at the resolution required by the "consumer" EDR.

2.1.1.2.1 VIIRS Granulate Ancillary

The sub-algorithms invoked by the VIIRS Granulate Ancillary Controller class, ProAncViirsController, correspond one-to-one to each component product enumerated below.

2.1.1.2.1.1 ViirsAncWindSpeedType

This type represents the wind speed and is granulated by the ProAncViirsGranulateWindSpeed sub-algorithm of the ProAncViirsController class. Ancillary inputs are U-Wind and V-Wind.

2.1.1.2.1.2 ViirsAncWindDirectionType

This type represents the wind direction and is granulated by the ProAncViirsGranulateWindDirection sub-algorithm of the ProAncViirsController class. Ancillary inputs are U-Wind and V-Wind. Wind direction is defined as the direction that the wind is blowing towards.

2.1.1.2.1.3 ViirsAncGeopotentialHeightType

This type represents the geopotential height at pressure layers and is granulated by the ProAncViirsGranulateTerrainGeopotentialHeight sub-algorithm of the ProAncViirsController class. Inputs are surface geopotential height, surface temperature, corrected surface pressure, terrain geopotential height, and water vapor mixing ratio.

2.1.1.2.1.4 ViirsAncOzoneType

This type represents the total column ozone and is granulated by the ProAncViirsGranulateOzone sub-algorithm of the ProAncViirsController class.

2.1.1.2.1.5 ViirsAncPrecipWaterType

This type represents the precipitable water and is granulated by the ProAncViirsGranulatePrecipWater sub-algorithm of the ProAncViirsController class.

2.1.1.2.1.6 ViirsAncPresLevelTempType

This type represents the temperature at pressure layers and is granulated by the ProAncViirsGranulatePresLevelTemp sub-algorithm of the ProAncViirsController class.

2.1.1.2.1.7 ViirsAncWaterVaporMixRatioType

This type represents the water vapor mixing ratio at pressure layers and is granulated by the ProAncViirsGranulateWaterVaporMixRatio sub-algorithm of the ProAncViirsController class.

2.1.1.2.1.8 ViirsAncSpecSurfHumidityType

This type represents the surface specific humidity and is granulated by the ProAncViirsGranulateSpecSurfHumidity sub-algorithm of the ProAncViirsController class.

2.1.1.2.1.9 ViirsAncSurfPresType

This type represents the corrected surface pressure and is granulated by the ProAncViirsGranulateSurfPres sub-algorithm of the ProAncViirsController class. Inputs are surface pressure, surface geopotential height, surface specific humidity, surface temperature, and terrain geopotential height.

2.1.1.2.1.10 ViirsAncSurfTempType

This type represents the surface temperature and is granulated by the ProAncViirsGranulateSurfTemp sub-algorithm of the ProAncViirsController class.

2.1.1.2.1.11 ViirsAncTropoGeopotentialHeightType

This type represents the tropopause geopotential height and is granulated by the ProAncViirsGranulateTropoGeopotentialHeight sub-algorithm of the ProAncViirsController class.

2.1.1.2.1.12 ViirsAncSurfGeopotentialHeightType

This type represents the surface geopotential height and is granulated by the ProAncViirsGranulateSurfGeopotentialHeight sub-algorithm of the ProAncViirsController class.

2.1.1.2.1.13 ViirsAncNitrateDepletionType

This type represents the nitrate depletion temperature and is granulated by the ProAncViirsGranulateNitrateDepletion sub-algorithm of the ProAncViirsController class.

2.1.1.2.1.14 ViirsAncBathymetryType

This type represents the digital bathymetry and is granulated by the ProAncViirsGranulateBathymetry sub-algorithm of the ProAncViirsController class.

2.1.1.2.1.15 ViirsAncTerrainHeightType

This type represents the terrain geopotential height and is granulated by the ProAncViirsGranulateGeopotentialTerrainHeight sub-algorithm of the ProAncViirsController class.

2.1.1.2.1.16 ViirsAncSkinTempType

This type represents the skin temperature and is granulated by theProAncViirsGranulateSkinTem sub-algorithm of the ProAncViirsController class.

2.1.1.2.1.17 ViirsAncOpticalDepthType

This type represents granulation of the Optical Depth data product either from NAAPS, granulated in the ProAncViirsOpticalDepth sub-algorithm or the AOT Climatology file, which is granulated in the ProAncViirsGranulateAotClimatology sub-algorithm, Both are sub-algorithms of the ProAncViirsController class.

2.1.1.2.1.18 ViirsAncNhfOzoneType

This type represents the total column ozone for NHF and is granulated by the ProAncViirsGranulateNhfOzone sub-algorithm of the ProAncViirsController class.

2.1.1.2.1.19 ViirsAncNhfPresLevelTempType

This type represents the temperature at pressure layers for NHF and is granulated by the ProAncViirsGranulateNhfPresLevelTemp sub-algorithm of the ProAncViirsController class.

2.1.1.2.1.20 ViirsAncNhfWaterVaporMixRatioType

This type represents the water vapor mixing ratio for NHF at pressure layers and is granulated by the ProAncViirsGranulateNhfWaterVaporMixRatio sub-algorithm of the ProAncViirsController class.

2.1.1.2.1.21 ViirsAncNhfSpecSurfHumidityType

This type represents the surface specific humidity for NHF and is granulated by the ProAncViirsGranulateNhfSpecSurfHumidity sub-algorithm of the ProAncViirsController class.

2.1.1.2.1.22 ViirsAncNhfSurfPresType

This type represents the corrected surface pressure for NHF and is granulated by the ProAncViirsGranulateNhfSurfPres sub-algorithm of the ProAncViirsController class.

2.1.1.2.1.23 ViirsAncNhfSurfTempType

This type represents the surface temperature for NHF and is granulated by the ProAncViirsGranulateNhfSurfTemp sub-algorithm of the ProAncViirsController class.

2.1.1.2.2 CrIMSS Granulate Ancillary

The sub-algorithms invoked by the CrIS Granulate Ancillary Controller class, ProAncCrisController, correspond one-to-one to each component product enumerated below.

2.1.1.2.2.1 CrisAncTerrainHeightType

This type represents the terrain geopotential height and is granulated by the ProAncCrisGranulateTerrainGeopotentialHeight sub-algorithm of the ProAncCrisController class.

2.1.1.2.2.2 CrisAncPresLevelTempType

This type represents the temperature at pressure layers and is granulated by the ProAncCrisGranulatePresLevelTemp sub-algorithm of the ProAncCrisController class.

2.1.1.2.2.3 CrisAncSurfPresType

This type represents the corrected surface pressure and is granulated by the ProAncCrisGranulateSurfPres sub-algorithm of the ProAncCrisController class. Inputs are surface pressure, surface geopotential height, surface specific humidity, surface temperature, and terrain geopotential height.

2.1.1.2.2.4 CrisAncSurfGeopotentialHeightType

This type represents the surface geopotential height and is granulated by the ProAncCrisGranulateSurfGeopotentialHeight sub-algorithm of the ProAncCrisController class.

2.1.1.2.2.5 CrisAncSurfTempType

This type represents the surface temperature and is granulated by the ProAncCrisGranulateSurfTemp sub-algorithm of the ProAncCrisController class.

2.1.1.2.2.6 CrisAncPresLevelMixRatioType

This type represents the water vapor mixing ratio at pressure layers and is granulated by the ProAncCrisGranulateWaterVaporMixRatio sub-algorithm of the ProAncCrisController class.

2.1.1.2.2.7 CrisAncSpecSurfHumidityType

This type represents the surface specific humidity and is granulated by the ProAncCrisGranulateSpecSurfHumidity sub-algorithm of the ProAncCrisController class.

2.1.1.2.3 OMPS TC Granulate Ancillary

The sub-algorithms invoked by the OMPS TC Granulate Ancillary Controller class, ProAncOmpsTcController, correspond one-to-one to each product enumerated below.

2.1.1.2.3.1 OmpsTcAncSurfPresType

This type represents the surface pressure and is granulated by the ProAncOmpsTcGranulateSurfPres sub-algorithm of the ProAncOmpsTcController.

2.1.1.2.3.2 OmpsTcAncCloudTopPresType

This type represents the cloud top pressure and is granulated by the ProAncOmpsTcGranulateCloudTopPres sub-algorithm of the ProAncOmpsTcController. The ancillary input is cloud top pressure.

2.1.1.2.3.3 OmpsTcAncUVSurfReflectType

This type represents the ultraviolet surface reflectance and is granulated by the ProAncOmpsTcGranulateUVSurfReflect sub-algorithm of the ProAncOmpsTcController. The ancillary input is ultraviolet surface reflectance.

2.1.1.2.3.4 OmpsTcAncPresLevelTempType

This type represents the atmospheric temperature profile at Umkehr pressure layers and is granulated by the ProAncOmpsTcGranulatePresLayerTemp sub-algorithm of the ProAncOmpsTcController. Two ancillary data inputs are required. The first ancillary input is temperature profile forecast data. The second ancillary input is the TOMS V8 temperature profile climatology, which is at Umkehr pressure layers. The temperature profile forecast data is used to populate Umkehr layers 1-7. Multiple pressure levels of the forecast data are “binned” into a single Umkehr layer. Because forecast data does not extend high enough into the atmosphere to populate Umkehr layers 8-11, data from the TOMS V8 climatology is used at these layers.

2.1.2 Algorithm Processing

Granulate Ancillary software is implemented based on its distinct function described as follows:

- Granulate Ancillary: Referencing external ancillary gridded data to a sensor’s swath.

Because interpolation is done in map grid coordinates, no special code is required to handle irregularity at the poles or discontinuity at 180 degrees longitude.

As indicated in Section 2.1.1.2, each specific ancillary data product is granulated by a respective class. The granulation algorithms copy the data out of the grid and apply specific resampling needed for that product.

2.1.2.1 Main Module

Granulate Ancillary's function is to resample ancillary information from a grid to the swath of a sensor. Ancillary products come in a variety of projection grids--e.g. Cylindrical Equidistant and Polar Stereographic. For all VIIRS products other than Digital Bathymetry and Terrain Geopotential Height, and all CrIS products other than Terrain Geopotential Height, this resampling is accomplished through the use of a generic mapping framework that returns a non-sensor specific structure of type ProAncCedMapping.

All OMPS products, VIIRS Digital Bathymetry, VIIRS Terrain Geopotential Height, and CrIS Terrain Geopotential Height utilize sensor specific mapping classes which return a sensor specific structure of type Grid2ModViirsGranule, Grid2CrisGranule, or Grid2OmpsTcGranule. All of these mapping classes, both generic and sensor specific, are used to map each swath pixel used in the spatial bilinear interpolation to a grid row, column, and source (North, South for Polar Stereographic)—i.e. the swath data is mapped to a grid where the interpolation is executed.

Currently, Digital Bathymetry and Terrain Geopotential Height (SRTM30_PLUS) data are resampled using Nearest Neighbor. The remaining Ancillary products use bilinear interpolation from sensor utility classes (used to go from swath to grid) for resampling.

2.1.3 Graceful Degradation

There are two cases where input graceful degradation is indicated in the Granulate Ancillary product.

1. The primary input denoted in the algorithm configuration guide cannot be successfully retrieved but alternate input can be retrieved.
2. Graceful degradation is indicated when an input Anc Int item (NCEP, FNMOC, NAAPS, Earth Orientation) are found to be using an extended forecast.

Table 4 details the instances of these two cases for Gran Anc.

Table 4. Graceful Degradation Detail

Description	Baseline Data Source	Primary Backup Data Source	Secondary Backup Data Source	Tertiary Backup Data Source	Graceful Degradation Done Upstream
Digital Bathymetry Database	VIIRS_GD_12.4.1 SRTM30_PLUS	N/A	N/A	N/A	No
Geopotential Height Profile	VIIRS_GD_11.4.4 NCEP	VIIRS_GD_11.4.4 NCEP (Extended Forecast)	N/A	N/A	No
Nitrate Depletion Temperatures	VIIRS_GD_13.4.1 Univ. of Florida (Kendal Carder) database	N/A	N/A	N/A	No
Total Column Ozone	VIIRS_GD_09.4.1 NCEP	VIIRS_GD_09.4.1 NCEP (Extended Forecast)	N/A	N/A	No
Total Column Precipitable Water	VIIRS_GD_09.4.11 NCEP	VIIRS_GD_11.4.3 NCEP (Extended Forecast)	N/A	N/A	No
Atmospheric Temperature Profile, VIIRS and CrIS	VIIRS_GD_11.4.3 NCEP	VIIRS_GD_11.4.3 NCEP (Extended Forecast)	N/A	N/A	No
Atmospheric Temperature Profile, OMPS TC	OMPS_GD_01.4.3 NCEP/Climatology	OMPS_GD_01.4.3 NCEP/Climatology (EF)	OMPS_GD_01.4.9 Climatology	N/A	No
Skin Temperature	NCEP	NCEP (Extended Forecast)	N/A	N/A	No
Specific Humidity at Surface	VIIRS_GD_09.4.12 NCEP	VIIRS_GD_09.4.12 NCEP (Extended Forecast)	N/A	N/A	No
Geopotential Surface Height	NCEP	NCEP (Extended Forecast)	N/A	N/A	No
Adjusted Surface Pressure, VIIRS and CrIS	VIIRS_GD_28.4.1 NCEP	VIIRS_GD_28.4.1 NCEP (Extended Forecast)	N/A	N/A	No
Surface Pressure, OMPS TC	OMPS_GD_01.4.2 NCEP	OMPS_GD_01.4.2 NCEP (EF)	OMPS_GD_01.4.8 TUG87	N/A	No
Surface Air Temperature	VIIRS_GD_09.4.10 NCEP	VIIRS_GD_09.4.10 NCEP(Extended Forecast)	N/A	N/A	No
Tropopause Height	VIIRS_GD_09.4.6 NCEP	VIIRS_GD_09.4.6 NCEP (Extended Forecast)	N/A	N/A	No
Terrain Geopotential Height	TerEco Tiles	N/A	N/A	N/A	No
Water Vapor Mixing Ratio at Pressure Levels	ALL_GD_01.4.4 NCEP	ALL_GD_01.4.4 NCEP (Extended Forecast)	N/A	N/A	No
Sea Surface Wind Speed and Direction	ALL_GD_01.4.2 NCEP	ALL_GD_01.4.2 NCEP	N/A	N/A	No

Description	Baseline Data Source	Primary Backup Data Source	Secondary Backup Data Source	Tertiary Backup Data Source	Graceful Degradation Done Upstream
		(Extended Forecast)			
Aerosol Optical Thickness	VIIRS_GD_27.4.1 NAAPS	VIIRS_DG_27.4.1 NAAPS (Extended Forecast)	VIIRS_GD_15.4.1 Climatology	N/A	No
Cloud Top Pressure Climatology	OMPS_GD_01.4.1 Climatology	N/A	N/A	N/A	No
Ultra Violet Surface Reflectivity	OMPS_GD_01.4.11 Climatology	N/A	N/A	N/A	No

2.1.4 Exception Handling

The code for bilinear interpolation of data from the grid to a swath verifies that all points are valid before doing the interpolation. If any of the input grid points are invalid or fill, the interpolation is not done and the pixel will be filled with a fill value. Geolocation containing fill data results in the respective pixel of the granulated product being set to fill. Geolocation containing invalid data that is not fill data will cause the algorithm to fail.

2.1.5 Data Quality Monitoring

No data quality monitoring tests are performed on this IP.

2.1.6 Computational Precision Requirements

The computation requirements for Granulate Ancillary mirror those of the products it produces and consumes. For the most part, single precision floating-point precision is required.

2.1.7 Algorithm Support Considerations

The DMS and INF must be running before any of the Granulate Ancillary products can be executed. A C++ compiler is needed to compile the algorithms.

2.1.8 Assumptions and Limitations

This section discusses the assumptions and limitations associated with the algorithms.

2.1.8.1 Assumptions

All necessary data is available and provided within the necessary time constraints.

2.1.8.2 Limitations

None.

3.0 GLOSSARY/ACRONYM LIST

3.1 Glossary

Table 5 contains terms most applicable for this OAD.

Table 5. Glossary

Term	Description
Algorithm	A formula or set of steps for solving a particular problem. Algorithms can be expressed in any language, from natural languages like English to mathematical expressions to programming languages like FORTRAN. On NPOESS, an algorithm consists of: A theoretical description (i.e., science/mathematical basis) A computer implementation description (i.e., method of solution) A computer implementation (i.e., code).
Algorithm Configuration Control Board (ACCB)	Interdisciplinary team of scientific and engineering personnel responsible for the approval and disposition of algorithm acceptance, verification, development and testing transitions. Chaired by the Algorithm Implementation Process Lead, members include representatives from IWPTB, Systems Engineering & Integration IPT, System Test IPT, and IDPS IPT
Algorithm Verification	Science-grade software delivered by an algorithm provider is verified for compliance with data quality and timeliness requirements by Algorithm Team science personnel. This activity is nominally performed at the IWPTB facility. Delivered code is executed on compatible IWPTB computing platforms. Minor hosting modifications may be made to allow code execution. Optionally, verification may be performed at the Algorithm Provider's facility if warranted due to technical, schedule or cost considerations.
Ancillary Data	Any data which is not produced by the NPOESS System, but which is acquired from external providers and used by the NPOESS system in the production of NPOESS data products.
EDR Algorithm	Scientific description and corresponding software and test data necessary to produce one or more environmental data records. The scientific computational basis for the production of each data record is described in an ATBD. At a minimum, implemented software is science-grade and includes test data demonstrating data quality compliance.
Environmental Data Record (EDR)	[IORD Definition] Data record produced when an algorithm is used to convert Raw Data Records (RDRs) to geophysical parameters (including ancillary parameters, e.g., cloud clear radiation, etc.). [Supplementary Definition] An Environmental Data Record (EDR) represents the state of the environment, and the related information needed to access and understand the record. Specifically, it is a set of related data items that describe one or more related estimated environmental parameters over a limited time-space range. The parameters are located by time and Earth coordinates. EDRs may have been resampled if they are created from multiple data sources with different sampling patterns. An EDR is created from one or more NPOESS SDRs or EDRs, plus ancillary environmental data provided by others. EDR metadata contains references to its processing history, spatial and temporal coverage, and quality.
Model Validation	The process of determining the degree to which a model is an accurate representation of the real-world from the perspective of the intended uses of the model. [Ref.: DoDD 5000.59-DoD Modeling and Simulation Management]
Model Verification	The process of determining that a model implementation accurately represents the developer's conceptual description and specifications. [Ref.: DoDD 5000.59-DoD Modeling and Simulation Management]
Operational Code	Verified science-grade software, delivered by an algorithm provider and verified by IWPTB, is developed into operational-grade code by the IDPS IPT.
Operational-Grade Software	Code that produces data records compliant with the System Specification requirements for data quality and IDPS timeliness and operational infrastructure. The software is modular relative to the IDPS infrastructure and compliant with IDPS application programming interfaces (APIs) as specified for TDR/SDR or EDR code.

Term	Description
Raw Data Record (RDR)	[IORD Definition] Full resolution digital sensor data, time referenced and earth located, with absolute radiometric and geometric calibration coefficients appended, but not applied, to the data. Aggregates (sums or weighted averages) of detector samples are considered to be full resolution data if the aggregation is normally performed to meet resolution and other requirements. Sensor data shall be unprocessed with the following exceptions: time delay and integration (TDI), detector array non-uniformity correction (i.e., offset and responsivity equalization), and data compression are allowed. Lossy data compression is allowed only if the total measurement error is dominated by error sources other than the data compression algorithm. All calibration data will be retained and communicated to the ground without lossy compression. [Supplementary Definition] A Raw Data Record (RDR) is a logical grouping of raw data output by a sensor, and related information needed to process the record into an SDR or TDR. Specifically, it is a set of unmodified raw data (mission and housekeeping) produced by a sensor suite, one sensor, or a reasonable subset of a sensor (e.g., channel or channel group), over a specified, limited time range. Along with the sensor data, the RDR includes auxiliary data from other portions of NPOESS (space or ground) needed to recreate the sensor measurement, to correct the measurement for known distortions, and to locate the measurement in time and space, through subsequent processing. Metadata is associated with the sensor and auxiliary data to permit its effective use.
Retrieval Algorithm	A science-based algorithm used to 'retrieve' a set of environmental/geophysical parameters (EDR) from calibrated and geolocated sensor data (SDR). Synonym for EDR processing.
Science Algorithm	The theoretical description and a corresponding software implementation needed to produce an NPP/NPOESS data product (TDR, SDR or EDR). The former is described in an ATBD. The latter is typically developed for a research setting and characterized as "science-grade".
Science Algorithm Provider	Organization responsible for development and/or delivery of TDR/SDR or EDR algorithms associated with a given sensor.
Science-Grade Software	Code that produces data records in accordance with the science algorithm data quality requirements. This code, typically, has no software requirements for implementation language, targeted operating system, modularity, input and output data format or any other design discipline or assumed infrastructure.
SDR/TDR Algorithm	Scientific description and corresponding software and test data necessary to produce a Temperature Data Record and/or Sensor Data Record given a sensor's Raw Data Record. The scientific computational basis for the production of each data record is described in an Algorithm Theoretical Basis Document (ATBD). At a minimum, implemented software is science-grade and includes test data demonstrating data quality compliance.
Sensor Data Record (SDR)	[IORD Definition] Data record produced when an algorithm is used to convert Raw Data Records (RDRs) to calibrated brightness temperatures with associated ephemeris data. The existence of the SDRs provides reversible data tracking back from the EDRs to the Raw data. [Supplementary Definition] A Sensor Data Record (SDR) is the recreated input to a sensor, and the related information needed to access and understand the record. Specifically, it is a set of incident flux estimates made by a sensor, over a limited time interval, with annotations that permit its effective use. The environmental flux estimates at the sensor aperture are corrected for sensor effects. The estimates are reported in physically meaningful units, usually in terms of an angular or spatial and temporal distribution at the sensor location, as a function of spectrum, polarization, or delay, and always at full resolution. When meaningful, the flux is also associated with the point on the Earth geoid from which it apparently originated. Also, when meaningful, the sensor flux is converted to an equivalent top-of-atmosphere (TOA) brightness. The associated metadata includes a record of the processing and sources from which the SDR was created, and other information needed to understand the data.
Temperature Data Record (TDR)	[IORD Definition] Temperature Data Records (TDRs) are geolocated, antenna temperatures with all relevant calibration data counts and ephemeris data to revert from T-sub-a into counts. [Supplementary Definition] A Temperature Data Record (TDR) is the brightness temperature value measured by a microwave sensor, and the related information needed to access and understand the record. Specifically, it is a set of the corrected radiometric measurements made by an imaging microwave sensor, over a limited time range, with annotation that permits its effective use. A TDR is a partially-processed variant of an SDR. Instead of reporting the estimated microwave flux from a specified direction, it reports the observed antenna brightness temperature in that direction.

3.2 Acronyms

Table 6 contains terms most applicable for this OAD.

Table 6. Acronyms

Term	Expansion
AM&S	Algorithms, Models & Simulations
API	Application Programming Interfaces
ARP	Application Related Product
CDFCB-X	Common Data Format Control Book - External
DMS	Data Management Subsystem
DPIS ICD	Data Processor Inter-subsystem Interface Control Document
DQTT	Data Quality Test Table
INF	Infrastructure
ING	Ingest
IP	Intermediate Product
LUT	Look-Up Table
MDFCB	Mission Data Format Control Book
QF	Quality Flag
SDR	Sensor Data Record
SI	International System of Units
TBD	To Be Determined
TBR	To Be Resolved
TOA	Top of the Atmosphere
VCM	VIIRS Cloud Mask

4.0 OPEN ISSUES

Table 7. TBXs

TBX ID	Title/Description	Resolution Date
None		